

VIBRATIONAL SENSING IN MARINE INVERTEBRATES

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LONG-TERM GOALS

My long-term goal is to understand important interactions among organisms, particles (including sediments), solutes and moving fluids. The reason for this goal is to be able to solve interesting forward and inverse problems dealing with marine biota.

OBJECTIVES

My current objectives under this grant are to determine what biological information can be obtained from acoustic backscatter arising at and on both sides of the sediment-water interface. Previous efforts under this grant also included assessments of the abilities of benthic animals to sense vibrations, explaining the grant title, which is now outdated.

APPROACH

My approach to date has been to work with acoustical oceanographers, specifically with Darrell Jackson and Kevin Williams of the Applied Physics Laboratory and with existing acoustic devices, namely BAMS (Benthic Acoustic Monitoring System). BAMS operates at 40 and 300 kHz, whereas XBAMS operates at only 300 kHz but has higher scan speed and more storage capacity. The approach has been extended more recently to work also with Van Holiday of Tracor Applied Sciences in looking at backscatter caused by animals that migrate out of the seabed after dark and return before sunrise. This phenomenon is better known from tropical reef habitats and fresh water, where it is known as "emergence." TAPS operates at multiple frequencies, but the frequency that shows the phenomenon most clearly in our case is 265 kHz. Both devices were used in the ORCAS experiment conducted in summer of 1995. As part of the ORCAS experiment, we manipulated abundances of several benthic species within the scan region of BAMS.

WORK COMPLETED

We have completed analysis of a set of STRESS (Sediment Transport Events on Shelves and Slopes) data records for putative biological signals (Jumars et al. 1996). We have completed analysis of the ORCAS BAMS results and have prepared a draft

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manuscript that will be submitted in FY98. We put the last steps aside to analyze the STRATAFORM data in time for a January 1998 meeting by PIs of that program. That analysis of the is still underway.

RESULTS

In the ORCAS program we observed approximately a 10 dB increase in 300 kHz backscatter from the small bivalve *Acila*, cockle *Clinocardium*, and bait treatments. The shrimp, burrow mimic, heart urchin, burrowing sea cucumber, mound-and-pit mimic and diver-control treatments discussed in last year's annual report did not show consistent, statistically significant changes.

Time series analysis of 40 kHz backscatter did not uncover significant changes due to any of the treatments. The stochastic analysis required, however, that we characterize the dynamic nature of the acoustic environment. The 40 kHz backscatter time dependency fits a nonstationary moving average process, i.e., an ARIMA(0,1,1) model. Given the nature and magnitude of the background noise structure, we estimate that a sustained 4 dB or greater deviation would be required before detection occurs.

To date, we find relatively little spatial structure (patchiness) in the backscatter data from the STRATAFORM site. This lack of spatial structure is consistent with the small body sizes and burrowing life-styles of the dominant organisms at the Eel River site (Wheatcroft, personal communication).

In the TAPS record from the ORCAS experiment, we find consistent nocturnal emergence by mysid shrimp to dominate backscatter from the water at 265 kHz. The pattern is analogous to the open-water DSL, except that the animals transit from the benthos rather than from the deeper water column. Just as the cloud of mysids leaves the seabed and just upon re-entry, we expect it to dominate near-bed acoustic behavior at this frequency.

IMPACT

Our first manuscript on biological information from low-angle, benthic acoustics (Jumars et al. 1996) has generated considerable interest on the part of both US and European workers on benthos, because there is no other way to get large-scale, frequent data on benthic organisms. The ORCAS work is the first to document that patches of infauna can affect backscatter at low grazing angles and might be confused with man-made objects on the bottom. We suspect that the stochastic analyses that we developed for the ORCAS analyses will find use for detecting changes to the seabed when they are published. Similarly, we expect our documentation of emergence to be of use in identifying dusk and dawn as particularly difficult times to search acoustically near the seabed.

We have also completed manuscripts based on earlier ONR work. Although they are consistent with my long-term goals, they do not fall under my present objectives. One is the first visualization of real diatom chains in a well characterized flow, and

it shows that chains rotate in shear much faster than do smooth, rigid cylinders of comparable dimensions (Karp-Boss and Jumars, in review). The second is a review paper of the effects of near-bed flows on macroscopic benthos (Jumars et al., in review). The fact that we were invited to participate in this revisitation of the marine benthic boundary layer, 20 years after the Les Arcs meeting that opened coherent interdisciplinary study on it, is evidence of success in achieving my long-term goals.

TRANSITIONS

We are unaware of any transitions at this early stage of the acoustics work. We expect our observations of diatom chains (including breakage in shear) to be of use in ONR-sponsored programs dealing with release of organic materials by phytoplankton in shear flows. Part of the reason that I maintain a web site is to make transition of the ongoing acoustics results easy for an end user.

RELATED PROJECTS

I have also been involved in initial planning for the shallow-water acoustics DRI that begins in FY98. Current collaborators are Darrell Jackson (APL UW), Kevin Williams (APL UW) and Van Holliday (Tracor Applied Science).

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Further information, graphics and links to related work can be found at the following url:

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